TECHNICAL CONSIDERATIONS

GLASS WORKSHOP

CANBERRA SCHOOL OF ART

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This paper has been written as part of the

Final Year requirements for the Degree of

BACHELOR OF ARTS (VISUAL)

GLASS DEPARTMENT

CANBERRA SCHOOL OF ART

CANBERRA A.C.T.

AUSTRALIA

NOVEMBER 1987

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INTRODUCTION

Technical considerations are perhaps the biggest hurdle facing students of glass. The medium has many facets and each requires a new understanding of processes and development of skill. During the four years in glass at Canberra School of Art, students are exposed to a variety of approaches to the glass medium:

- **fused glass** - perhaps the strongest element of the workshop
- **casting** - both hot glass casting and kiln casting
- **refractory mould preparation** - for casting and slumping
- **sculptural casting process** - adapted for glass
- **hot glass** - glass blowing

The philosophy of the workshop is to provide a facility for students to come and develop their own ideas. Other than gaining a basic introduction to the fundamental steps associated with the disciplines listed above, undergraduates work independently of each other. From the second year on students, with the approval of the workshop head set their own syllabus and working program. The result of this is a diverse approach to far differing areas of the glass medium. The work and the needs of the students from the workshop differ just as markedly, particularly the need for specific technical information to realise ideas. Rough outlines for exploration can be set by tutors, however like much of the rest of the program students often find it necessary to experiment with processes as well as the properties of the material.

Experimenting with the properties of the glass associated with the relative area of study can be a long and expensive process. Working through the physical limitations imposed by the brittle material usually occupies most of the student's time, energy and money during their stay in the workshop. Unfortunately at the end of their degree students often take the four years of research with them. It is for this reason I have decided to concentrate this paper on the research into technical processes I have either developed or existing information I have expanded upon during my degree. Focussing upon the fusing methods used in my work, this has been the main area of study. The fusing process which was developed during final year also encompassed a couple of other disciplines and techniques - mould preparation and slumping.

It is my aim to give a brief and clear outline of the processes used in my art work as documentation for future students whose work may lean in a similar direction, or those who require specific information for a particular stage of work. Hopefully this may help to overcome the weight of technical processes and time-stealing research needed in the workshop.

I have paid considerable attention to difficulties associated with the work I have been producing, spending only brief time marking out the fundamental steps associated with each process. This is because of the volume of information involved and the fact that most basic steps are already documented.

The paper has been written on the premise that the reader has some general understanding of the glass medium and specifically, a basic understanding of kiln working. For an introduction to fusing consult **"The Bullseye Fusing Book"** by Lundstrom and Schwoerer. Although this book provides an excellent background to the basic disciplines associated with these areas, it quickly becomes obvious to students of glass that it is but the tip of the iceberg.

MOULD PREPARATION

A mould basically is a fixed design or form into which a material is added to take the particular shape. The purpose of the mould determines the materials and type of mould used.

There are a number of considerations in producing a mould for glass. Firstly, the ease by which the material can be forged to the required shape, the need for the mould to withstand enormous temperature changes, whether the mould will be used once and discarded or several firings are required, and whether the mould materials will affect the glass.

My main requirement for moulds during final year was slumping. This is where my understanding of mould technology is most advanced and I have concentrated on it in this chapter. For an insight into casting recipes for moulds I recommend reading M. Rijsdijk Final Year Paper 1987.

Plaster Based Moulds

Initially I used a mixture of plaster, silica and other refractory materials, using the plaster to provide the binding agent for the other materials. The firing strength of the mould was basically determined by the percentage of plaster present in the mould. Plaster is the weak link in a mould used for firing, however it is necessary as a binder. Keeping the overall percentage of plaster to 25%-33% and no lower, can help overcome most of the cracking which is the main problem with plaster based moulds.

Cracking happens during the firing process and is due to the plasters or other inflexible material present in the mould not being able to expand with the temperature changes experienced during the firing. Different plasters have different success in tolerating heat, for example casting plaster has a better tolerance to heat than dental plaster. However the setting time for dental plaster is faster than casting plaster.

Another drawback when using plaster based moulds is the weakness or softness of the mould due to the low percentage of plaster. With such a small amount of plaster to suspend the other refractory material, crumbling or chipping is quite common once the mould is dry. This sets up a "Catch 22" situation where the amount of plaster used in the mould, whether it be large or small, has its relative problems with overall strength and durability compared with its ability to withstand thermal shock.

The advantage of a plaster based mould is its quick setting time (around 18 minutes), the ease at which the mould can be reshaped or carved, the ease with which the glass can be removed from the mould (as the mould won't stick to the glass), the porous qualities of the mould allowing relatively easy transfer of heat and the amount of detail which can be obtained.

Plaster Based Recipe Procedure

2 parts plaster (CASTING PLASTER – $Ca.SO_4.2H_2O$)

2 parts silica flour (200 MESH – SiO_2)

1 part china clay (KAOLIN – $Al_2O_3.2SiO_2.2H_2O$)

1 part luto (MIXTURE OF PRE-FIRED MATERIALS, SUCH AS ABOVE)

This is mixed by volume, never weight, at a ratio of 2 : 1, two parts plaster/refractory mix to one part water. This provides a good guide for calculating the total quantity of mixed investment.

A guide for calculating the total volume of wet plaster mix required for a particular mould is as follows:

- Step 1 Calculate volume of mould (required input of wet plaster);
- Step 2 Calculate amount of water required;
- Step 3 Calculate amount of dry plaster required.

Step 1.

Multiply dimensions of required shape to be taken by mould, averaging out irregularities caused by design, to arrive at a total volume i.e. -

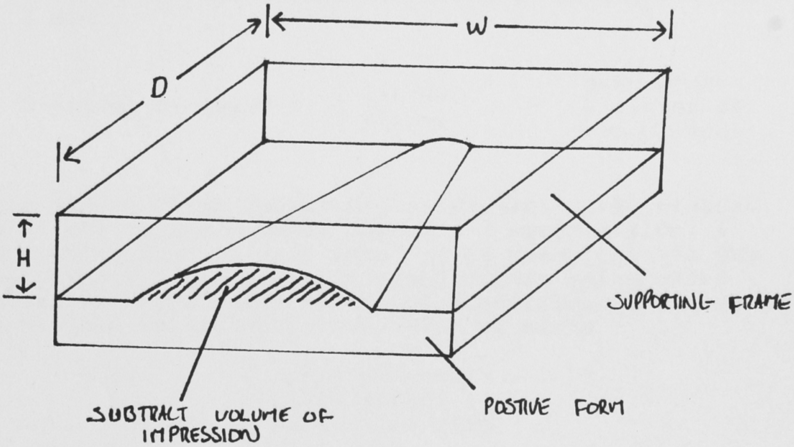
$$V = L \times W \times H$$

Where L = length
W = width
H = height
V = volume in cubic centimetres (cm3)

See example (Fig. 1)

FIG 1. CALCULATING VOLUME OF MOULD

$H \times D \times W = \text{Volume}$



For example, say V in Fig. 1 calculates out at 10,000 cm3 (10 litres) then subtract estimated volume of impression (add for depression). In the case of Fig. 1, say, the impression is 1,000 cm3 (1 litre) leaving a total volume requirement of 9 litres of wet plaster mix.

Step 2.

To calculate the total volume of water required use formula -

$$\text{Volume of water} = \frac{\text{Total volume of mould}}{1.5}$$

Continuing the example in Step 1 :

$$\text{Volume of water} = \frac{9 \text{ litres}}{1.5}$$

Therefore volume of water required is 6 litres.

Step 3.

To calculate the amount of plaster required, multiply amount of water x 2, since plaster is mixed at a ratio of 2 : 1 with water.

To finalise the example illustrated in Steps 1 and 2 above -

6 litres of water +	12 litres of plaster	=	just over 9 litres of wet plaster

When adding other refractory materials to the plaster as in the recipe 2 parts plaster, 2 parts silica, 1 part china clay, 1 part luto, it is essential all dry ingredients are thoroughly mixed before being added to water. Also remember the plaster/refractory mixture is divided according to the ratio of parts -

e.g.	2 parts plaster
	2 parts silica
	1 part china clay
	1 part luto
Total	6 parts.

Total parts is then divided by total litres of dry mix required. From the previous example, total of dry plaster/refractory mix was 12 litres

therefore $\frac{12 \text{ litres}}{6 \text{ parts}}$ = 2 litres per part

made up of	2 x 2 litres of plaster
	2 x 2 litres of silica
	1 x 2 litres of china clay
	1 x 2 litres of luto.

USES

'One off' castings are the best for plaster based moulds. They may also be useful for multiple slumpings if a stable base can be established. A kiln shelf is a good stable base to support the mould. However, monopolising a kiln shelf for the life of the mould is unwise due to the shortage of shelves within the workshop.

Plaster Sleeve, Castable Shell Mould (for slumping).

Castable shell plaster moulds was a process developed during final semester using a layer of plaster/refractory mix mould recipe, supported by a shell of stronger refractory casting material. High Alumina Castable (a cement grog mixture) was chosen due to its durability over a period of firings. Initially I used a straight 100% Alumina Castable mould, however Castable is an extremely rough material allowing only little detail. Also, a mould release is needed between the Castable surface and glass, further reducing the detail obtainable.

By utilising the strength of the Castable with the detail and release qualities of the plaster mould, a mould can be produced which should last twenty firings or more.

Recipe Procedure

Contain positive form for which mould is to be made in sections of glass, forming walls. Vaseline or shellac should be applied to the form to prevent sticking.

A layer of plaster/refractory mix is poured over the mould as described previously to about 5-8 cm deep (Fig. 2). The thickness of the plaster layer depends on the overall shape of the mould. It should provide enough support for the set plaster/refractory mix mould to be handled.

Once the mould has set it is removed from its retaining walls and its base and sides are covered with a heavy coat of shellac. This is to stop the plaster mix sticking to the Castable shell as Castable has a different coefficient of expansion to plaster. When exposed to heat if the Castable forms a bond on the plaster the mould will crack.

Another frame is built up about 3 cm larger than the plaster mould. A layer of Castable is placed in the frame and the plaster mix mould is set on top. The sides are filled only enough to stabilise the base (Fig. 3).

FIG 2. POURING PLASTER MOULD

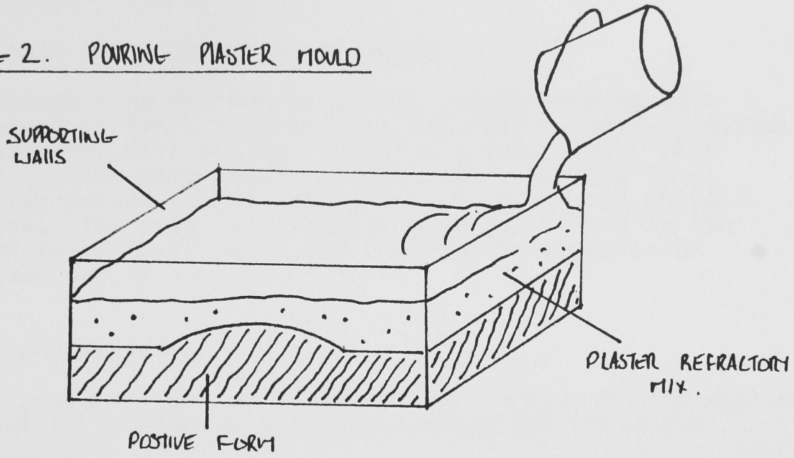
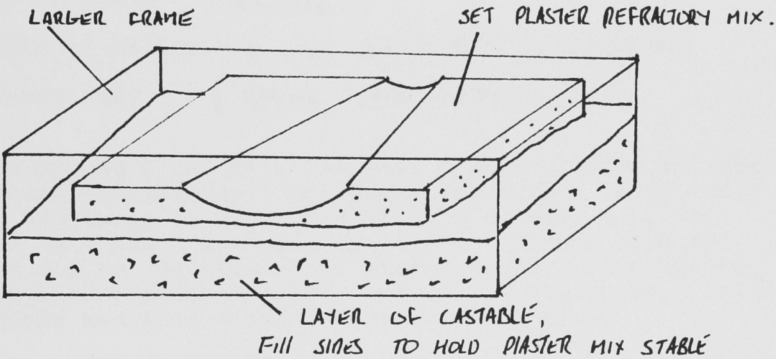


FIG 3. ADDING CASTABLE SHELL



To estimate quantities required use the formula previously used for the plaster mix. Castable's total volume does not change when mixed with water and it has a long setting time so it can be mixed as and when it is required. Castable should be mixed to the consistency of cement. Always add water to dry Castable in small amounts - never add Castable to water.

The mould should be left for 36 hours for the Castable to set. Once set it should be placed in a warm ventilated climate for a period of days depending on the size of the mould.

The principle can also be adapted for casting, perhaps using a very thin sleeve and slightly thinner wall of Castable depending on the type of casting needed. For further information on casting using a similar technique consult M. Rijsdijk Final Year Paper 1987.

Ceramic Shell Mould for Slumping

Although time did not allow the exploration of this process in 1987, I believe it can further solve problems associated with moulds. This is a very light, thin and quickly made mould, it does not require a long drying period and it can withstand incredible thermal shock. The only disadvantage with this mould is the need for a shelf paint and that the form cannot be carved out or changed.

Recipe/Procedure

The positive form or blank must be covered with a shellac paint to provide an adequate release for the mould.

<u>Recipe</u>:

Zircon Flour - $ZrSiO_4$

Coloidal Silica - (FINE SILICA HELD IN SUSPENSION)

Zircon sand - (ZIRCON SAND MIXTURE)

Mix Zircon flour with Coloidal Silica to make a light creamy consistency. Dip mould in mixture or if mould is too large to dip, pour thin layer over top, say 1-2 cm thick. Sprinkle on layer of Zircon sand and let dry for 30 minutes in warm climate. Continue to mix Zircon flour - Silica mixture as otherwise it will settle and form a solid mass very quickly.

Repeat this step until a shell of about 4-5 mm is obtained, usually about 4-5 coats. The mould is returned to a warm climate and allowed to dry for 2-3 hours. Once set, all that remains is to apply a mould release before slumping. If a totally smooth surface is required a rather thick mould paint will have to be built up.

Mould Releases

Any material that does not stick to the glass during the firing and remains stable during the firing can be used for a mould release. These include:

Talc Powder ($3MgO . 4SiO_2 . H_2O$)
Alumina Hydrate ($AL_2O_3 . 3H_2O$)
China Clay (KAOLIN - $AL_2O_3 . 2SiO_2 . 2H_2O$)
Whiting (CALCIUM CARBONATE - $CaCO_3$)
Luto (MIXTURE OF PRE FIRED MATERIALS)

Depending on the type of surface required various combinations of these or other materials with similar properties can be used. For example if a rough or sandy finish is needed add Alumina Hydrate as it has a fine sand quality; if a super smooth finish is required talc can be added.

I have noted a couple of the more successful release paints used as follows:

- Mix 50% talc with 50% china clay; mix in water to a milky consistency; then several layers can be brushed on to the dry or damp mould.

- Mix 75% Alumina Hydrate with 25% china clay; mix and apply as above.

- Mix 75% Whiting with 25% china clay; mix and apply as above.

Note: Moulds must be totally dry before glass is added (see pre firing moulds immediately below).

Pre Firing Moulds

The amount of pre firing necessary for each mould is determined by the overall mould size. Pre firing is necessary to remove all physical water and chemical water which is present and held within the mould. "Physical water" is water trapped within the mould after the binders have set. "Chemical water" is water forming in the mould due to a chemical reaction. This occurs at 600°C and only happens during the first firing.

It is essential that the mould is dry, especially for slumping as water trapped between the glass and the mould will turn to steam and invariably crack the glass. Therefore a pre firing of the mould without glass is a good idea.

Procedure

Once the mould is touch dry, i.e. has been kept in a warm climate for 3-5 days, the mould can be heated slowly (10°C per hour for large moulds, 20°C per hour for smaller moulds) to 120°C. Vents should be left open to allow steam to disperse. Leave mould at 120°C until all apparent water has evaporated. Check this by holding clear glass over vent, mould is dry when moisture film does not build up on the clear glass surface.

Raise temperature at 50°C per hour to 600°C and hold for 30 minutes. During this final ramp to 600°C check for moisture build up as before; if apparent hold temperature until dispersed. This may prove necessary more than once during the ramp. Once fired, kiln is turned off and mould is allowed to return to room temperature.

FUSING

Fusing in glass terms means combining various glass components through intense heat to a single form. Fusing has an enormous number of approaches in the principles of working techniques, individual situations and their working patterns. This is important to remember as all the tried and tested information supplied has been performed within the workshop at the Canberra School of Art. Other working environments may give differing results when employing information from this Chapter.

The main areas of fusing work during final year included lamination, pate de verre and slumping. I adapted existing information on all these processes to arrive at a working procedure relevant to my work.

To arrive at a successful working formula it is necessary to research the various ideas and brilliant mistakes (successful accidents) through a testing stage until a result is achieved that solves the original aesthetic question. I have set out a working pattern for the fusing techniques employed in my work, at the same time trying to point out relative properties of the material and pitfalls associated with these areas of fusing.

Properties of Glass/Working Procedure

> "You can never force the glass to behave in a certain way, at best you can encourage it to do so".(1)

Glass is a fluid frozen in a solid state. The artist can only ever set up a situation for the glass and return it to a fluid state. The fluid material obviously cannot be handled in the same way that clay can. So the artist must rely on known qualities of the material and the force of gravity to manipulate the glass in a desired direction.

It is only through experience one builds up the language for interpreting the information from a firing and an awareness for glass and its properties. The fusing formula developed during final year was the result of over one hundred firings; out of this I will have about five pieces of finished work! The bulk of the firings were exploring the various properties of the Bullseye glass range.

(1) Keith Cummings **"Glass Forming"**, A.H. & A.W. Reed 1980 (Page 39)

Bullseye was the only glass used for fusing, this was an obvious choice because of the compatibility requirements combined with the selections of colours available. The Bullseye fusing range has certain properties which are worth noting as a guide for fusing and slumping.

Bullseye is a fairly soft glass, low temperature slumping glass, softer than window glass yet harder than lead glass. This is important to note especially for casting or sharp edge slumping. The softer the glass, the easier the glass will flow and the more detail will be obtainable. Different glass within the Bullseye range has differing levels of softness with most transparents and black opal being the softest through to clear being the stiffest.

Colour change through heat was another quality worth noting about the Bullseye range. Various colours especially softer glasses had little change to their structure or original colour. Black for instance had on occasions been fired ten or more times with no apparent changes in structure or colour. By contrast some sheets of light grey opalescent No. 133 turned bright yellow after one firing.

Over a period of firings, or one firing to a very high temperature (900^{o}C+), most Bullseye glasses crystallised and as a result became more brittle. This affects the strength of the glass and its ability to fuse or slump evenly. The hotter the firing schedule the more the glass structure is affected as certain fluxes in the glass are burnt away.

The list below contains some of the more common Bullseye glasses and their relative properties.

Colour	**Glass No.**	**Properties**
Black	100	Softest opalescent glass: can withstand numerous firings; crystallises above 900^{o}C
Clear	101	Hardest glass tested yet not prone to devitrification; can be fired a number of times; retains the same stiffness throughout
Red Orange	124 125	Soft glass; very unstable, colour will invariably fade or darken depending on the individual sheet

Gold Pink	SP 311	Softer glass; expensive; has a habit of turning opaque mud during firing
Yellow	120	Firm glass; holds colour well, vulnerable to light devitrification
Lime Green	126	Excellent fusing glass; soft not prone to any devitrification or crystallisation
Blue Blue	116 114	Medium stiffness; tendency to turn slightly pasty from original colour; prone to heavy surface devitrification
Green	122	Hard glass; maintains colour well; vulnerable to very heavy surface devitrification; strong pigment base
Pink	301	Firmer glass; colour changes from sheet to sheet and changes through various firings from pink to mauve; unstable and prone to heavy surface devitrification
Irridised Glasses		Incredibly high surface tension; irridisation forms a hard stable skin; still slumps well.

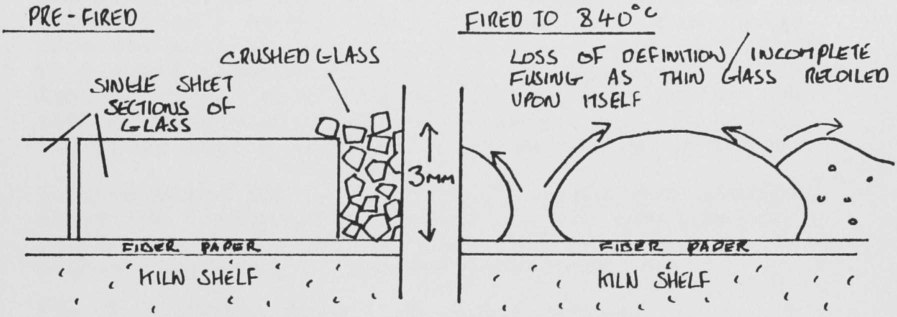
This information illustrates the variables involved with combining Bullseye glass through a series of firings. The qualities were experienced through the range of temperatures required to fuse the glass 850°C to low temperature slumpings and fire polishing, 630°C. It is important to consider the properties of a particular glass relative to the effect desired of the glass.

Surface Tension

Glass is a fluid with a particularly high surface tension. As it is heated through its softening point to melting point the glass will pull up on itself as water droplets do when splashed on a smooth surface. The surface tension is highest when the glass is in a semi-liquid state, about 770°C. Over this temperature the glass becomes molten and surface tension is overpowered by gravity and begins to flow outwards again.

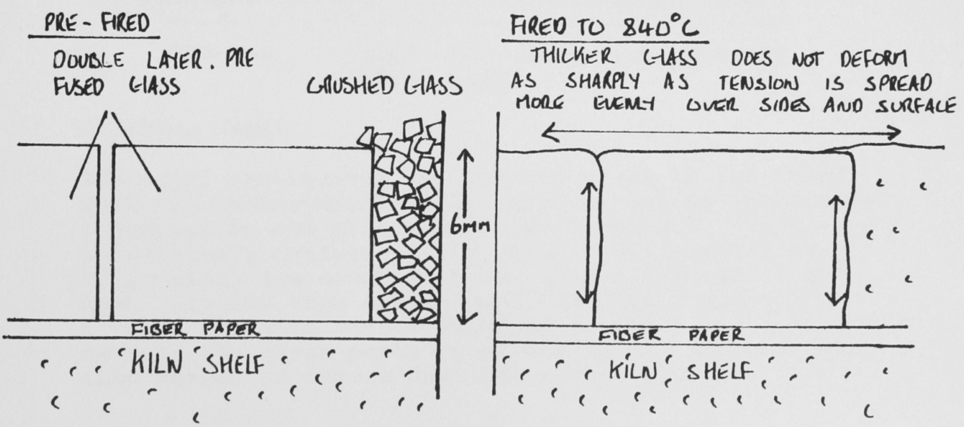
This was the first problem with the retention of definition in the mosaic design fusings, as the early designs were cut from single sheets of glass (Fig. 4).

FIG 4. CROSS SECTION OF SINGLE LAYER FUSING



The answer was to fuse thicker sections of glass which accommodated the surface tension. Thicker sections, say two or more layers of glass, react less violently to surface tension as the stress is dispersed more evenly over sides as well as surface (Fig. 5).

FIG 5. CROSS SECTION OF TWO LAYER FUSING



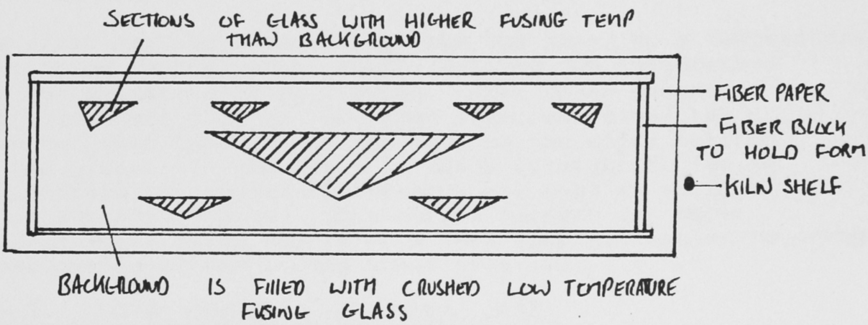
It is possible to lay a solid section over a single layer design to help stabilise the image, however there is still some deformation of line. It is also difficult to remove bubbles of air trapped under the top layer without taking the glass to a high fusing temperature which further deforms the design.

Glass Hardness

When fusing a design the selection of glass qualities was sometimes as important as colour decisions. For example a glass used to form the design image was usually chosen from a harder glass than the background glass. This was so that the background glass would melt first at a lower temperature and take the shape of the firmer design piece. As the harder piece became molten the softer background glass had already taken its shape, therefore little deformation in the design occurred.

I found Black 100 glass the softest and most flexible glass for backgrounds. Laying the pre fused and cut design components out on fibre frax paper and covering with a 4 mm layer of crushed glass (Fig. 6).

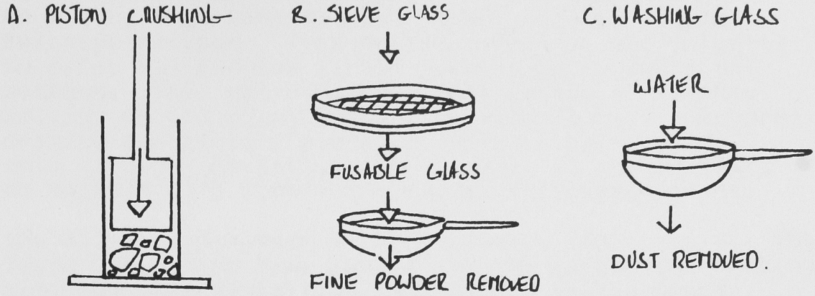
FIG 6. LAYING DESIGN OF FUSED SECTIONS



Crushing Glass

The major requirement for crushed glass in the fused work was backgrounds. After trying various techniques I settled on the piston crushing technique. This gave a relatively uniform grit size with few impurities. After glass was crushed it was sieved through 5 mm^2 mesh. It was then sieved again through a domestic kitchen sieve to remove fine powder which has a tendency to turn the glass pasty or crystalline. The grit was then washed to remove dust particles (Fig. 7).

FIG 7. CRUSHING GLASS



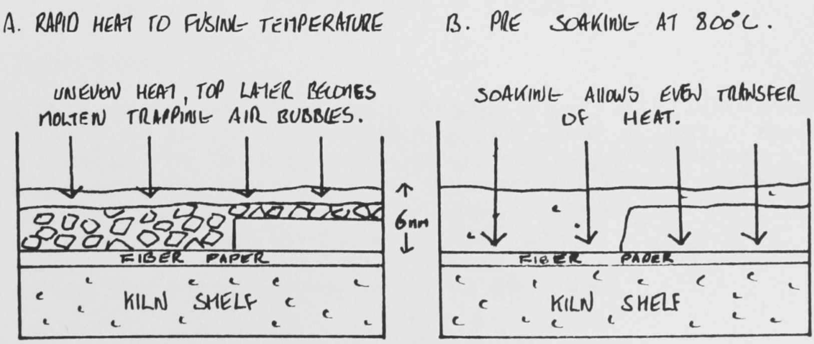
I found 5 mm - .5 mm particle size about right for this type of fused work. Larger particles would cause distortions or heavy bubbles. Too many fine particles would devitrify or change colour.

Fusing Cycle

The fused and cut design forms are laid out on fibre frax paper in accordance with the dimensions of the overall piece. They are then covered with a layer of crushed background glass, this is built up to about 4 - 5 mm deep.

The first heating stage is to take the glass to a temperature just below fusing, about 800°C, holding the temperature for approximately 30-60 minutes. This is to ensure the kiln shelf side of the image (the face side) has time to reach the same temperature as the upper surface of the glass. If the glass is taken straight to fusing temperature the chance of catching air bubbles on the image surface is high. This occurs because the upper surface melts first and forms a skin trapping air surrounding glass pieces closer to the shelf (Fig. 8).

FIG.8 CROSS SECTION OF FUSING SLAB.

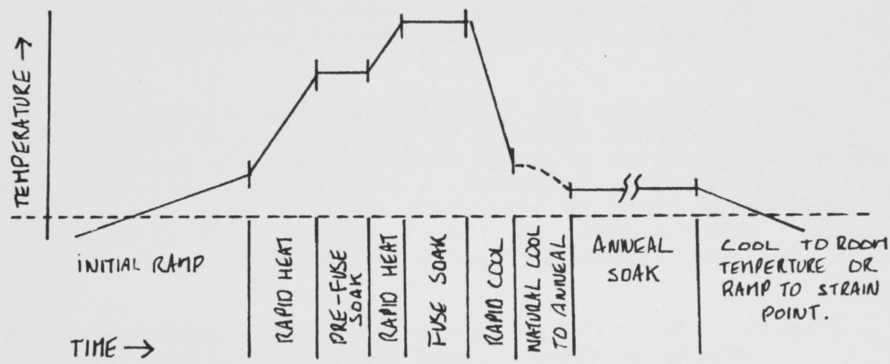


To remove air bubbles from deep in the piece trapped by a molten skin, it is necessary to take the glass to a very high temperature, 880°C - 890°C for most Bullseye glasses. This softens the skin sufficiently to offer the bubbles little resistance to reach the surface. This can also cause the design to distort heavily as the glass becomes totally molten. The pre-soaking temperature for Black 100 Bullseye is 790°C, this is a particularly soft glass so it is necessary to soak 20-25°C higher for harder Bullseye glasses.

The kiln is then pushed to the fusing temperature. The lower the fusing temperature and the longer the soaking time the more definition is retained in the design. Most pieces were soaked at 830°C for 40-50 minutes with a flash to 870°C for about 2-3 minutes to remove small bubbles trapped just under the surface.

Once fusing is completed, the kiln is cracked open and the inner temperature is rapid cooled to 600°C. When the kiln temperature is stable at 600°C the glass is semi solid again, the door is then closed and the kiln is allowed to cool naturally to the annealing 'phase'. I have provided a firing sequence for a typical fused form using these techniques (Fig. 9).

FIG 9. FIRING SEQUENCE GRAPH



Annealing

Glass must transfer from a liquid to a solid (frozen fluid) slowly so as not to retain any permanent stress. Strain is caused by different parts of the glass being at different temperatures; as the cooler section contracts at a different rate to the warmer sections stress develops. If excessive the stress will form cracks as the two sections pull against each other; this can happen long after the piece is removed from the kiln.

After researching the principles of annealing it becomes painfully obvious of the need to understand the particular stress points of the glass used. Unfortunately as yet there is no simple way to determine exactly these points, in fact most annealing schedules rely on estimations and experience. Kiln characteristics such as pyrometer accuracy, insulating materials and the natural cooling cycle all affect the annealing cycle of the glass.

There are two main points for annealing all glasses: the Annealing Point and the Strain Point.

- The annealing point is a temperature approximately 100°C above the strain point. The annealing point is where the whole temperature of the glass is stabilised. This temperature and time for stabilisation is determined by the overall thickness of the glass as well as taking into account other insulating material such as mould, kiln shelves etc.

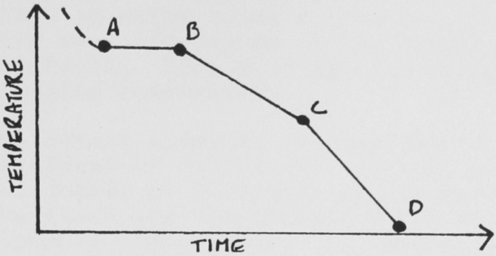
- The strain point is when the glass is substantially ridged, theoretically the glass has become a frozen fluid at this temperature. The rate at which the glass can be cooled from annealing point to strain point is again determined by thickness and insulation materials present.

Once temperature has been equalised the natural cooling cycle of the kiln is usually slow enough to accommodate glass 8 mm or thinner, provided there is no other insulating material present other than a kiln shelf. For thicker sections of glass or glass surrounded by heavy insulation materials it is necessary to cool the glass through these points at a slower rate than the natural cooling cycle.

I have provided a chart for annealing time and cooling rates for use with Bullseye glass. These schedules have been determined through experience and theorising. They are based on the annealing cycles used by the Czechoslovakian artist Stanislav Libinsky and transposed for use with Bullseye glass. They are intended as a guide to help approximate relative annealed schedules using the kilns and computers of the workshop at Canberra School of Art (Fig. 10).

FIG 10. ANNEALING SCHEDULES FOR BULLSEYE GLASS.

ANNEALING GRAPH



A. ANNEALING POINT
B. ANNEAL SOAKING TIME
C. COOLING RAMP FROM ANNEALING POINT TO STRAIN POINT (100°C BELOW ANNEAL)
D. COOLING RAMP FROM STRAIN POINT TO ROOM TEMPRATURE

ANNEALING TIMES / COOLING RATES

THICKNESS OF GLASS	A	A to B	B to C	°C PER HOUR	C to D	°C PER HOUR
3 mm	500°	30 min	—	NATURAL COOL	—	NATURAL COOL
6 mm	480°	2 HOURS	—	NATURAL COOL	—	NATURAL COOL
8 mm	475°	4·5 HOURS	4 HOURS	25°	6 HOURS	66°
12 mm	465°	10 HOURS	50 HOURS	2°	60 HOURS	6·6°
15 mm	460°	16 HOURS	96 HOURS	1·04°	110 HOURS	3·6°
20 mm	450°	25 HOURS	190 HOURS	·5°	210 HOURS	1·9°C

ALL SCHEDULES TO 8mm ARE FOR GLASS ON KILN SHELF WITH NO OTHER INSULATION MATERIAL PRESENT.

Using the information as a guide it is better to slightly overestimate the annealing time to avoid disaster, disappointment and depression!

Slumping

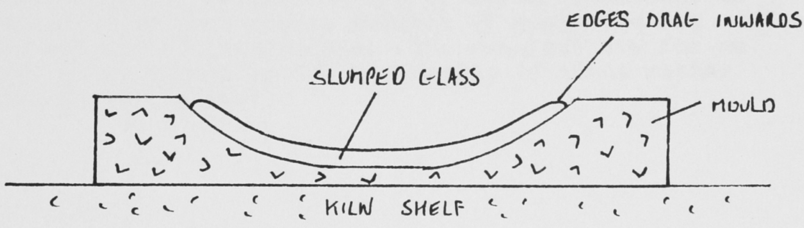
Slumping is the final heating phase for the glass and involves placing a pre fused platform over a prepared mould. The mould is made from refractory materials capable of tolerating the heat imposed by the slumping cycle. It is important that the materials used in the mould do not affect the glass (See Mould Preparation).

Once the mould has been pre fired and has returned to room temperature the fused glass is positioned over the mould. The heating cycle should be slow enough to allow for the mould to keep the same temperature as the glass. A pre slump soaking is therefore recommended. For the particular pieces I was using, 550°C appeared to be a good pre slump soaking temperature. This was held for up to one hour depending on mould thickness. From soaking, the glass was taken to the slumping temperature.

The actual slumping temperature is determined by the stiffness of the glass, the thickness of the glass and degree of sharpness of the mould form. The thinner the glass and the shallower the form the lower the slumping temperature. If unsure it is usually necessary to watch Bullseye glass from 600°C upwards. The usual range for slumping Bullseye glass is 640°C - 680°C. Like fusing it is better to work the glass slowly at a lower temperature to allow even transfer of heat through the glass.

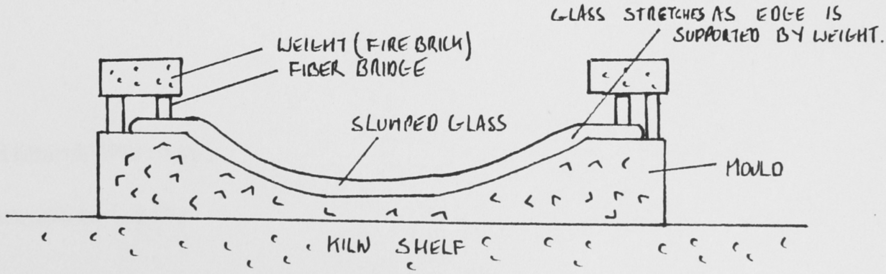
The slumped forms I was working during final semester had particular problems with slumping. This was due to the length of the slump in relation to the overall length of the piece. The glass had a tendency to pull its edges in towards the mould centre as the lips were not long enough to provide a firm base to resist the gravitational pull of the glass (Fig. 11).

FIG 11. CROSS SECTION OF SLUMPED GLASS



This was overcome by securing the lips of glass to the mould edge. A bridge was formed with fibre frax pieces and a weight, usually a refractory brick, was placed on top (Fig. 12). The fibre bridge allowed heat to circulate under the weight to stop formation of a cold spot.

FIG 12. CROSS SECTION OF SLUMPED GLASS WITH SUPPORTED EDGES



CONCLUSION

Compounded with the seductive qualities of glass as a raw material, there are also the technical difficulties associated with working in the medium. Many glass artists have difficulty in breaking free from technical considerations in their efforts to produce art work. There is I believe a risk of becoming entangled within a web of process and design in the technical use of glass at the expense of artistic expression and the conceptualising of ideas.

On the other hand my own experience indicates that a knowledge of working the medium is essential before reaching this creative second stage. In my own case I have found myself only lately coming to a point where it was possible to break free from the confines imposed by the technicalities of glass itself and to explore more spontaneous avenues of producing art through use of this medium. The eventual aim for me must be to become an artist working in glass rather than a glass artist.

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November 1987

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